CS325
USER INTERFACE AND USER EXPERIENCE DESIGN
Week 11

Dr Frank Guan

Agenda

- Direct manipulation
- Fitts' Law
- Steering Law
- Interactive devices
- Multi-window management
- Web/mobile UI design

Direct Manipulation

Imagine you’re driving

Interface: Steering wheel, pedals, etc.

Geographic area through which user (driver) maneuvers car is displayed directly in front of user (and in high resolution, and in large field of view!)

Manipulating steering wheel top to left (and right) causes car front to move left (and right) visual and kinetic feedback is immediate

Pushing brake pedal results in car slowing arbitrary mapping of user action to car maneuver (automatized) visual and kinetic feedback is immediate

Definition, again:

- User operates on a visually displayed “world” to perform tasks in a domain
- Here, the world on which the user operates, is the *real* world
- For computing tasks, there is the *task* world and an interface *model* world
- The user operates on the model world to change the task world

Direct Manipulation

- Described by Shneiderman in 1974
- **Definition:**
  - User operates on a visually displayed “world” to perform tasks in a domain
- Examples
  - WYSIWYG editors and word processors
  - CAD
  - Desktop metaphor
  - Video games
  - VR/AR

Compound document displayed on Xerox 8010 Star system

the first program to incorporate the WYSIWYG technology

The paper by Hutchins et al. 1985

- Provides a detailed analysis of the elements of direct manipulation

directness = *f*(distance, engagement)

- **Directness**
  - The feeling that results from interaction with an interface (direct vs. indirect)

Edwin L. Hutchins, James D. Hollan, and Donald A. Norman. Direct Manipulation Interfaces. in Human-Computer Interaction, Vol. 1, pp. 311-338, Lawrence Erlbaum Associates, Inc., 1985.

Two Aspects of **Directness** in Direct Manipulation

Distance and Engagement

directness = *f*(distance, engagement)

Distance

- "Distance" between user's *thoughts* and system's requirements for using it to perform task
  - (e.g., g32, s/edtor/editor - large distance)
- Short distance means translation between user's thoughts and system is simple and straightforward
  - (e.g., insert 'i', or type over "edtor" with "editor")
- Describes factors which underlie the generation of the feeling of directness

Engagement

- Feeling that the user is directly manipulating the objects of interest
  - e.g., dragging a subdirectory to another subdirectory VS. mv /usr/bob/*.* /usr/jo/

Direct Manipulation Essence

- Continuous visibility of the objects and actions of interest
- Rapid, reversable, incremental actions
- Replacement of command language syntax by direct manipulation of object of interest

Benefits of Direct Manipulation 1/2

- Novices can learn basic functionality quickly, usually through a demonstration by a more experienced user.
- Experts can work rapidly to carry out a wide range of tasks, even defining new functions and features.
- Knowledgeable intermittent users can retain operational concepts.
- Error messages are rarely needed.

Benefits of Direct Manipulation 2/2

- Users can immediately see whether their actions are furthering their goals, and if the actions are counterproductive, they can simply change the direction of their activity.

- Users experience less anxiety because the interface is comprehensible and be-cause actions can be reversed easily.

- Users gain a sense of confidence and mastery because they are the initiators of action, they feel in control, and they can predict the interface’s responses.

Direct Manipulation NOT Good At

- Repetition
- History keeping (harder)
- Certain tasks (Change all italics to bold)
- Macros harder
- Abstract elements (variables)

Translational distance

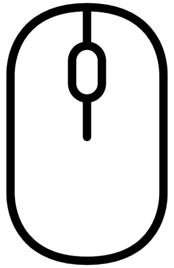
- To understand and categorize the direct-manipulation of metaphor is by looking at the translational distance between users and the representation of the metaphor, which will be referred to as strength.

- Strength can be perceived along a continuum from weak to immersive.

- Examples of translational distances (strength)
  - Weak—early video game controller
  - Medium—touchscreens, multi-touch
  - Strong—data glove, gesturing, manipulating tangible objects
  - Immersive—virtual reality, i.e, oculus rift

Weak Direct Manipulation

- Basic direct manipulation
- Use **mouse**, **trackpad**, **joystick**, or similar device to translate the user's physical action into action in the computer space using some mapping function
  - For example, the user moves the mouse on a 2-D desk within a small circum-scribed region and the mouse moves on the screen (again 2-D).
- However, these mapping functions are not always fully understood and processed correctly by the user, sometimes the user will actually run the mouse off the surface of the desk



Medium Direct Manipulation

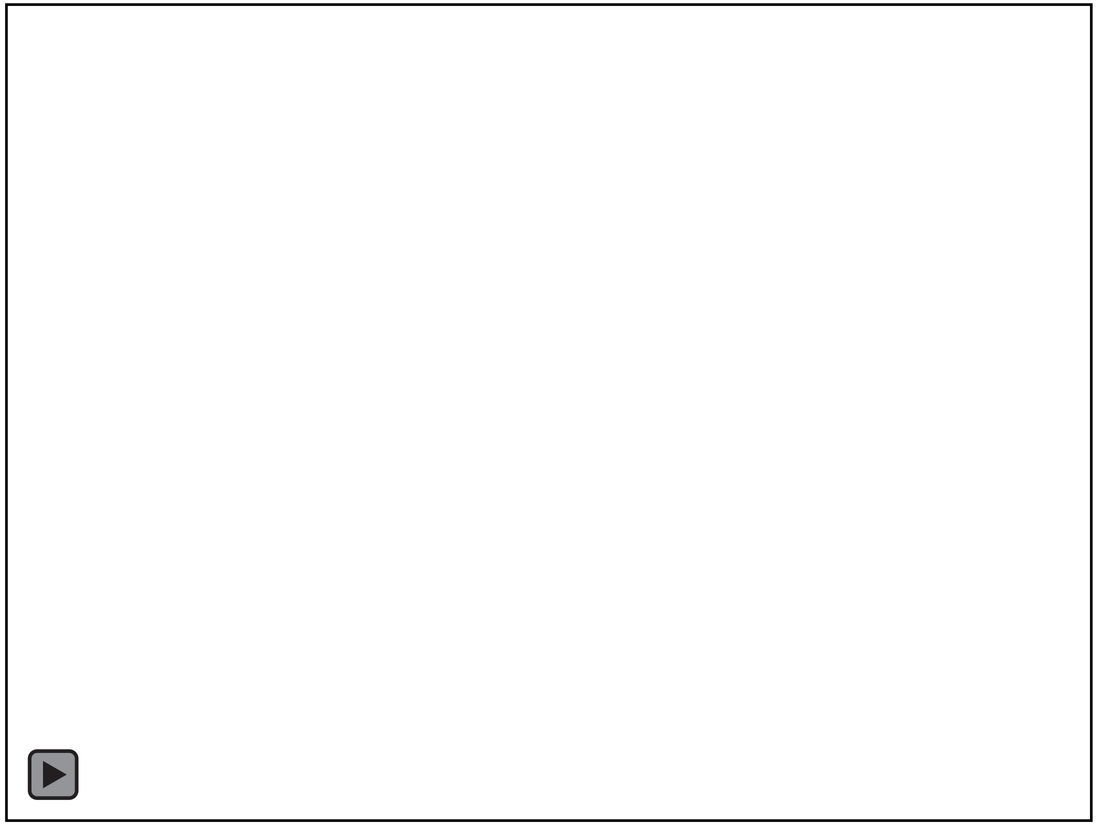
- The translational distance is reduced.

- Instead of communicating with the virtual space with the device, the user reaches out and touches, moves, and grabs the entities in the on-screen representation.
  - E.g. Three users working concurrently on a large tabletop touch device. They can use their hands/figures to manipulate the objects on the device. Note the different hand gestures being used.

https://www.invista.com.au/interactive-touch-tables-interactive-touch-panels/

Strong Direct Manipulation

- Involves actions such as gesture recognition with various body parts
  - Hand
  - Foot
  - Head
  - Full body
  - Speech
  - …



Immersive Direct Manipulation

- VR/AR Immersive Environment
- Bare hand
- Controllers

Problems with Direct Manipulation

- Consume valuable screen space thus forcing valuable information off-screen especially with mobile devices
- Users must learn the meanings of visual representations and graphic icons
- Mouse operations may be slower than typing
- Not self-explanatory (no prompts)
- Some direct-manipulation principles can be surprisingly difficult to realize in software.
  - E.g. Rapid and incremental actions have two strong implications: a fast perception/action loop (less than 100 ms) and reversibility (the undo action). A standard database query may take a few seconds to perform, so implementing a direct-manipulation interface on top of a database may require special programming techniques. The undo action may be even harder to implement, as it requires that each user action be recorded and that reverse actions be defined.

Pros and Cons of Direct Manipulation

Advantages	Disadvantages
• Easier to learn & remember • Direct WYSIWYG • Flexible, easily reversible actions helps reduce anxiety in users • Provides context & instant visual feedback • Exploits human use of visual spatial cues • Limits types of errors	• May be hard to program • Accessibility requires special attention

Fitts' Law

Mystery of Fitts' Law

Before we get to know Fitts's Law, let's solve the mystery of its name.

Paul M. Fitts was an American psychologist and one of the pioneers in improving aviation safety. He went on to lead the Psychology Branch of Air Force Research Laboratory – later renamed, in his honor, to Fitts Human Engineering Division.

Fitts's Law was his most famous work. It was first mentioned in a publication in 1954, and first applied to Human-Computer Interaction in 1978.

Unfortunately, Paul Fitts never witnessed that, having died unexpectedly in 1965, at the age of 53.

Fitts' Law (Fitts, 1954)

- Fitts' Law predicts that the time to point at an object using a device is a function of the distance from the target object & the object's size.

- The further away & the smaller the object, the longer the time to locate it & point to it.

- Fitts' Law is useful for evaluating systems for which the time to locate an object is important, e.g., a cell phone, a handheld devices.

Fitts' Law

- Models movement time for selection

- Movement time for a rehearsed task
  - Increases with distance to target (d)
  - Decreases with width of target (s)
  - Depends only on relative precision (d/s), assuming target is within arms reach

- First demonstrated for tapping with finger (Fitts 1954), later extrapolated to mouse and other input devices

Fitts' Law Equation

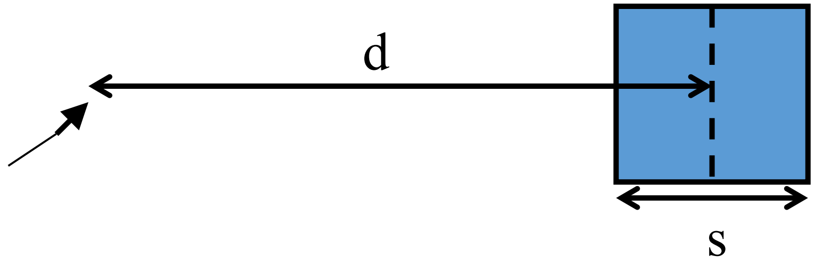
$T_{msec} = a + b \log_2 (d/s + 1)$

a, b = empirically-derived constants

d = distance

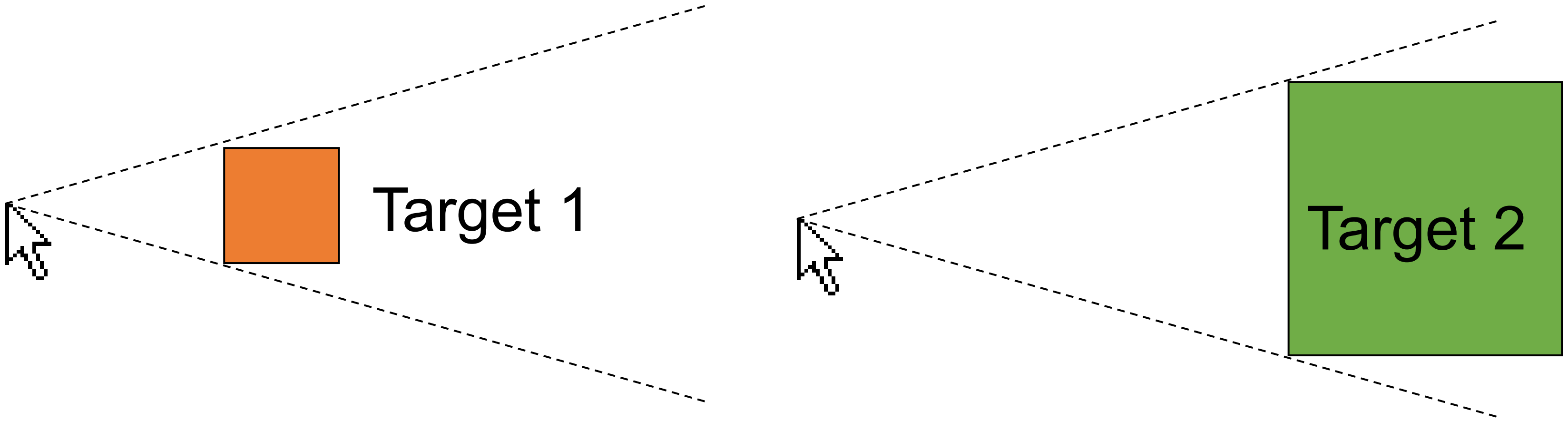
s = width of target

ID (Index of Difficulty) = $\log_2 (d/s + 1)$

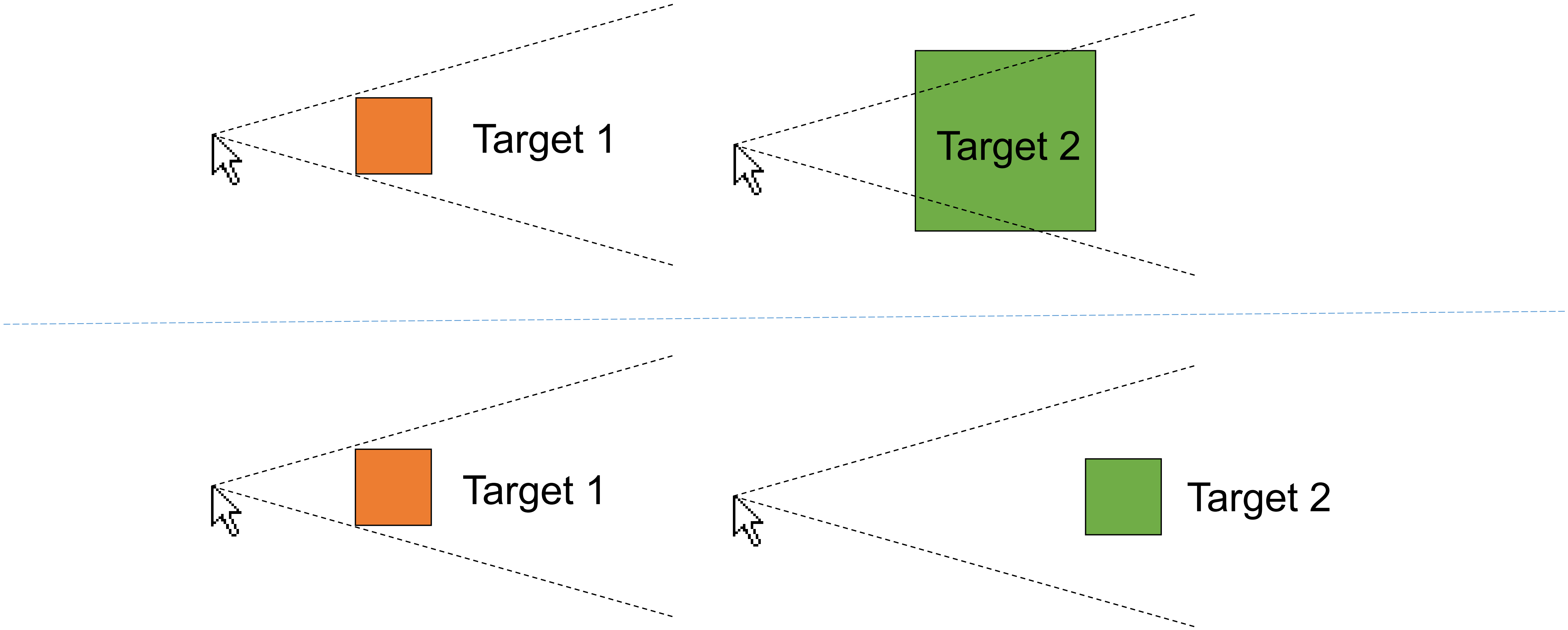


Fitts' Law intuition

- Time depends on *relative precision* (d/s)
- Time is not limited by motor activity of moving your arm / hand, but rather by the cognitive activity of keeping on track
- Below, time will be the same because the ratio d/s is the same



More examples



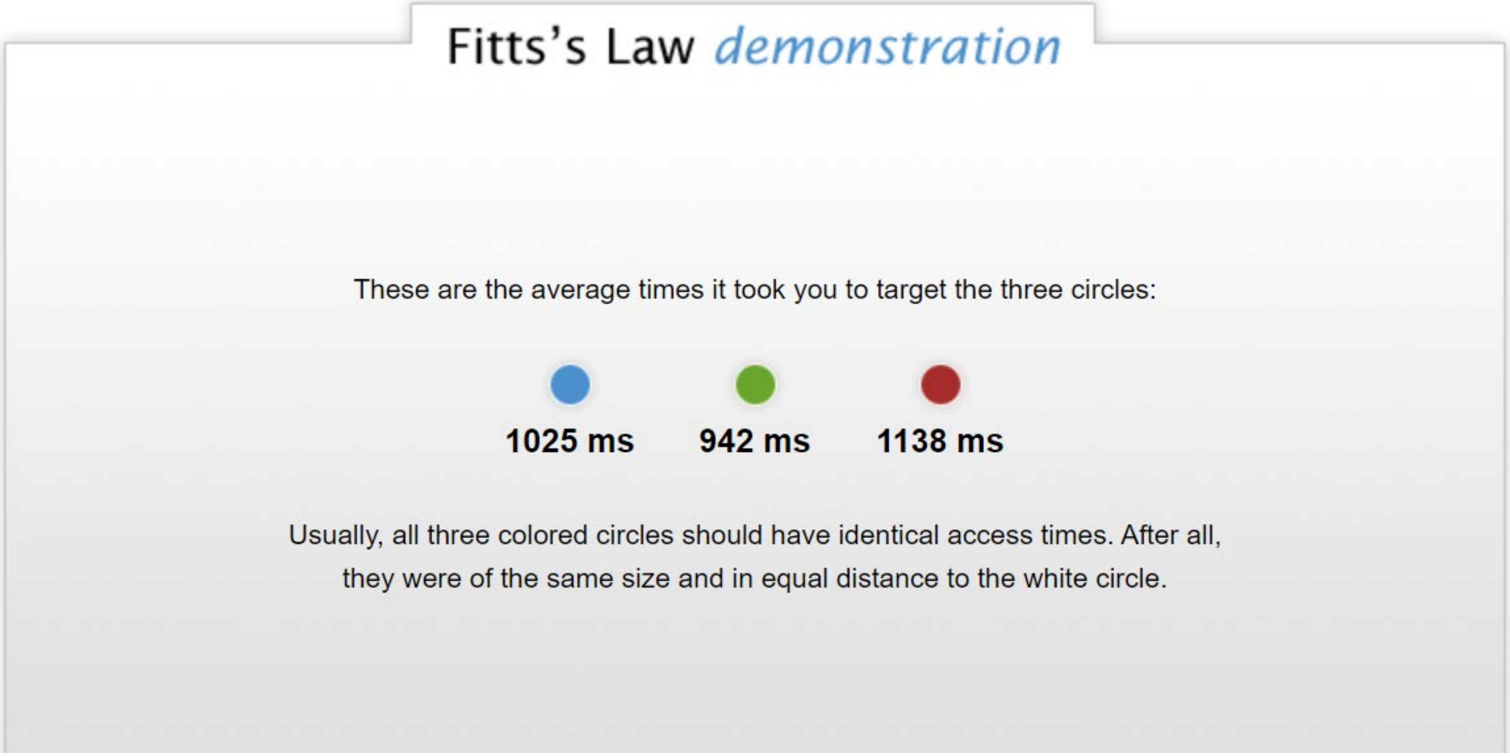
How to determine constants: *a* and *b*

- Conduct experiments varying d,s but keeping everything else the same
- Measure execution time, error rate, accuracy
- Exclude erroneous data
- Perform linear regression

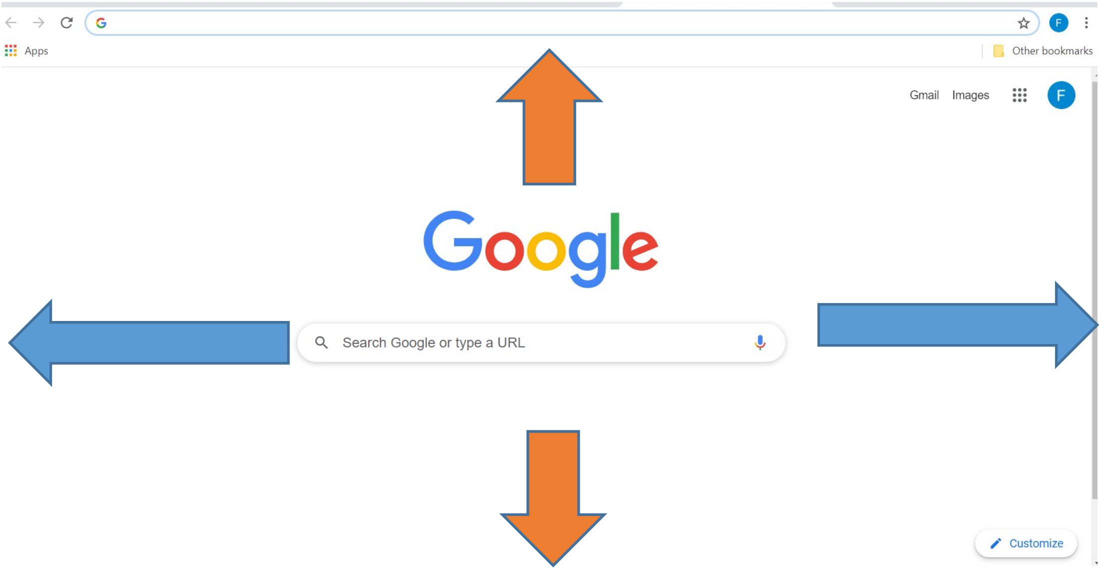
A simple test

Get your mouse ready!

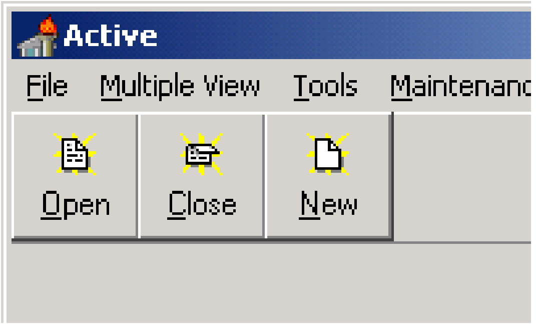
http://fww.few.vu.nl/hci/interactive/fitts/

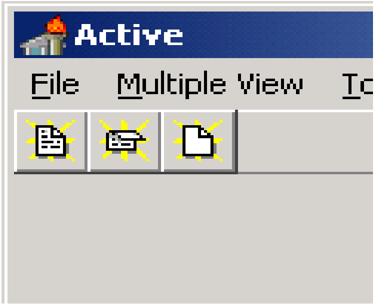


Fitts’ Law in practice



Which one is more efficient



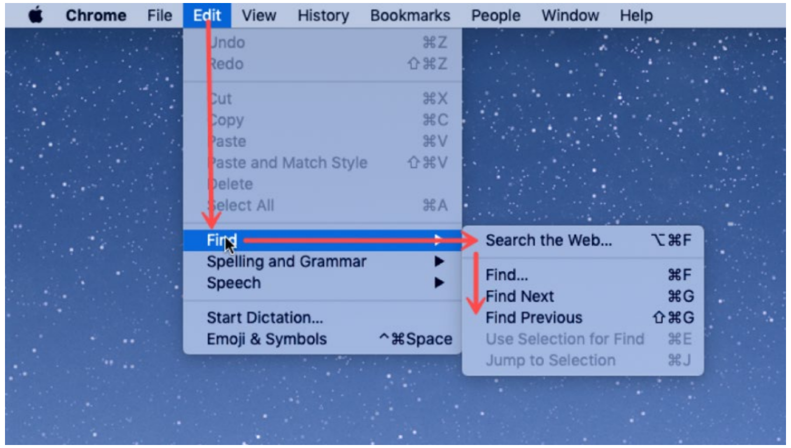


Steering Law

Steering Law

- Applies same principles to steering through a tunnel (Accot, Zhai 1997)

- A **tunnel** is any user-interface control that requires the user to move the cursor (or drag a finger on a touchscreen) along a **path that has borders**.



Steering Law Equation

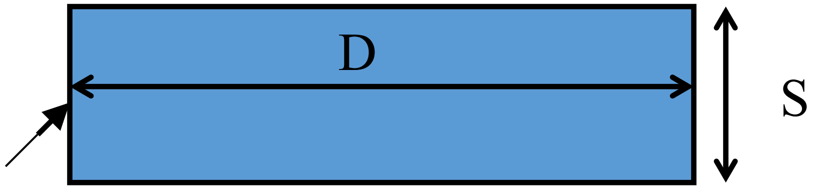
$T_{msec} = a + b\ (d/s)$

a, b = empirically-derived constants

d = distance

s = width of tunnel

ID (Index of Difficulty) = (d/s)



Index of Difficulty now *linear*, not logarithmic.

Interactive Devices

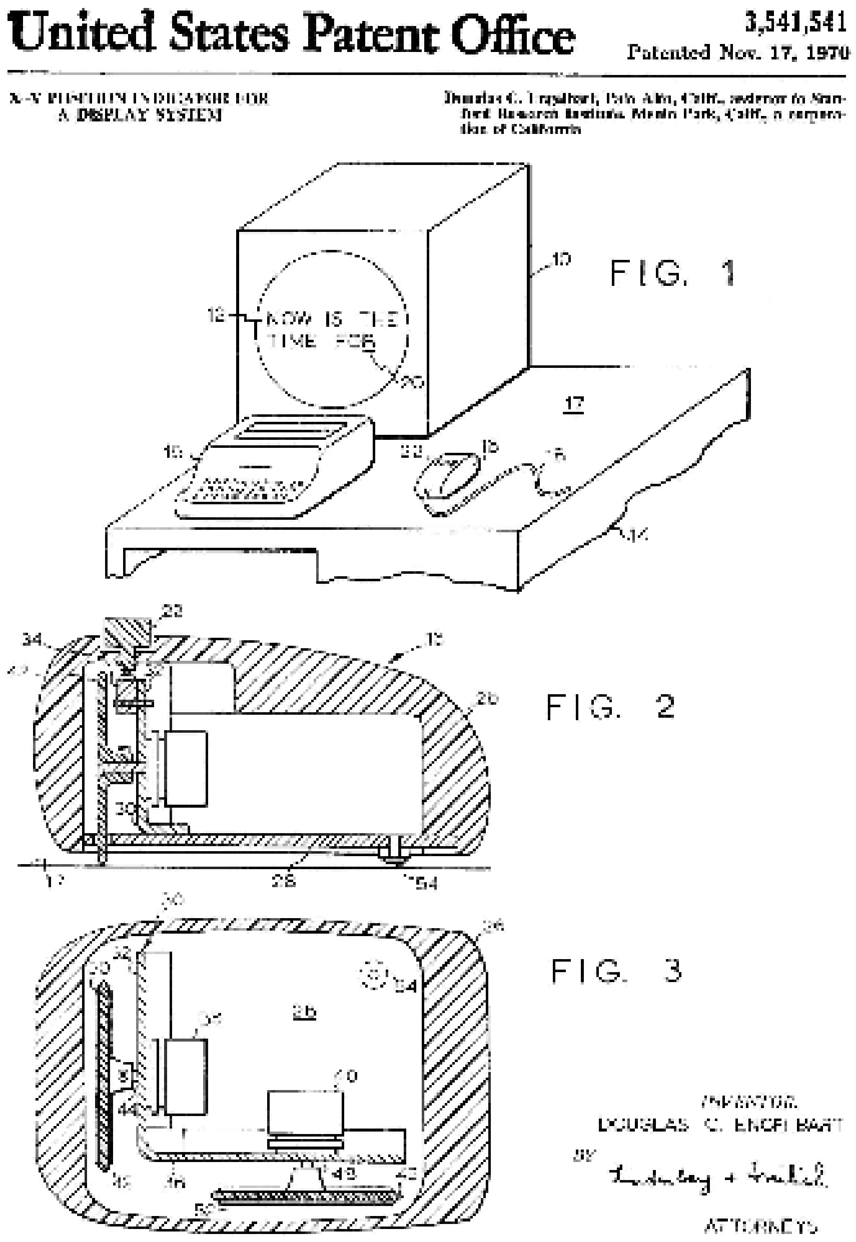
Interaction Devices

- Mouse
- Haptic devices
- Wearable devices
- Speech recognition

Mouse

The Mouse

Doug Engelbart’s mouse, Stanford Research Lab, 1964



The first Computer Mouse was invented by Douglas Carl Engelbart.

The patent was issued by the United States Patent Office on November 17, 1970.

Types

- **Mechanical Mice -** Mechanical Mice requires that the mouse be set on a flat surface. The distance and the speed of the rollers inside the mouse determine how far the mouse cursor moves on the screen depending on the software configuration.

Mechanical Mouse

- **Opto-Mechanical -** The optical-mechanical hybrid consists of a ball which rolls a wheel inside the mouse. This wheel contains a circle of holes and or notches to read the LED by a sensor as it spins around when the mouse is moved. This mouse is much more accurate than the mechanical mouse.

- **Optical Mice –** Older Optical Mice required a special mouse pad which had a grid pattern. A sensor inside the mouse determines the movement by reading the grid as the mouse passes over it while emitting a light from an LED or sometimes a laser. Recent Optical Mice no longer have the disadvantages of earlier mice and are capable of being utilised on any surface.

Optical Mouse

How Mouse Works

https://www.youtube.com/watch?v=eccSwn9QVxo

Haptics Devices

Haptics

A science concerned with the sense of touch

Cutaneous: Sense based on skin receptors

Kinesthesia: perception of limb movement and position, include the perception of force as well

Cutaneous and kinaesthetic are parallel sources

(a) Omni

(b) Desktop

(c) SPIDAR

(d) Falcon

3D Touch & Taptic Engine

Latest development

https://www.youtube.com/watch?v=8BZ1JnnBwgI

Wearable Devices

Wearable Computing

Study or practice of inventing, designing, building, or using miniature body-borne computational and sensory devices

Steve Mann (1996)


ANDERTON

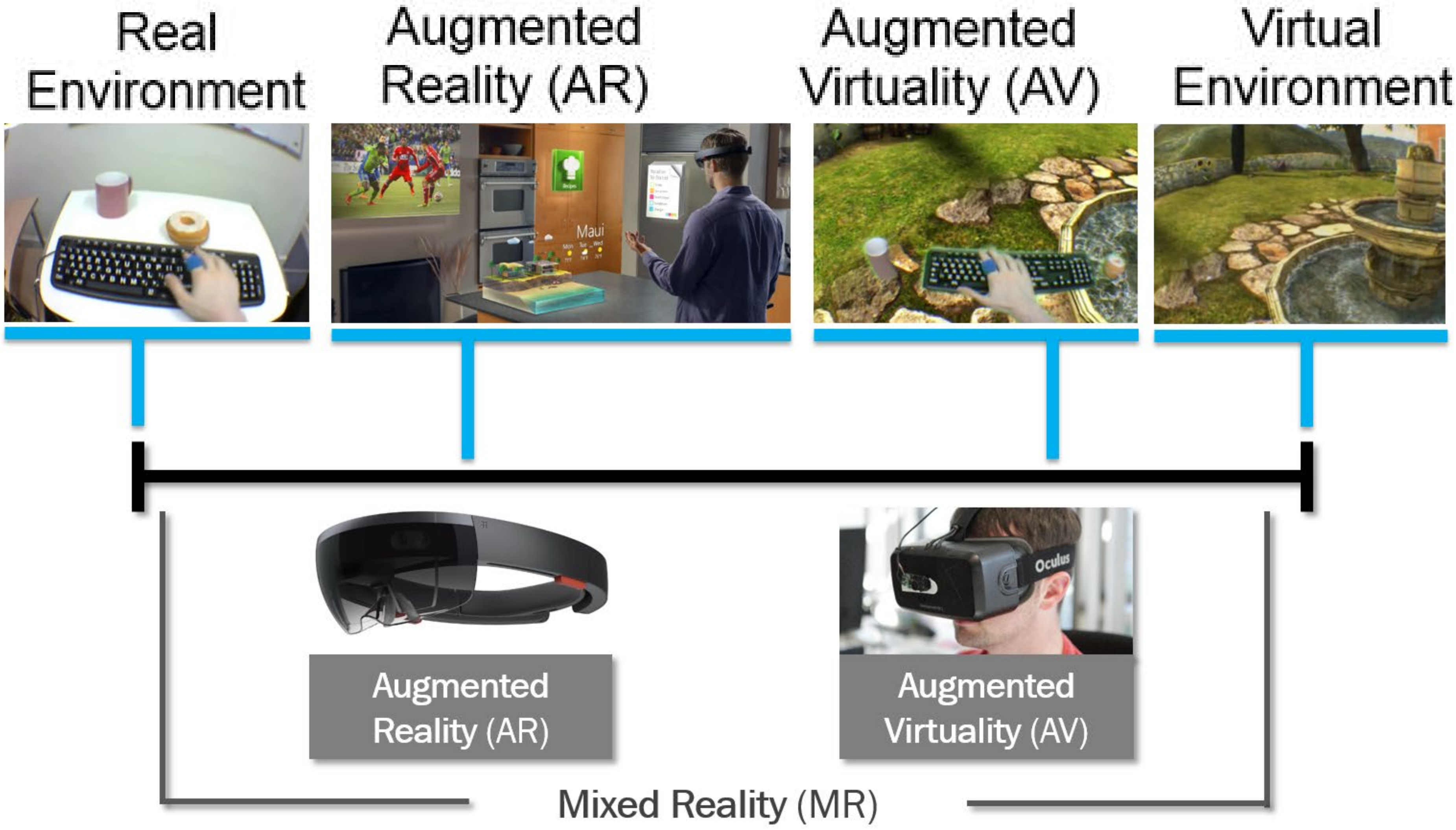

10:09
Sunrise 6:45AM
Sunset 7:27PM
Cupertino, CA
10:09
GOAL
JAWBONE
12680
fitbit

Steve Mann's "wearable computer" and "reality mediator" inventions of the 1970s have evolved into what looks like ordinary eyeglasses.

(a) 1980 | (b) Mid 1980s | (c) Early 1990s | (d) Mid 1990s | (e) Late 1990s


Europress / Getty

Milgram’s Reality-Virtuality (RV) Continuum



Speech Recognition

Speech Input

- Speech synthesis
- Speaker recognition
- Speech recognition
- Natural language understanding

English Speech

- Made up of 40 phonemes, 24 consonants and 16 vowels

Speech Synthesis

- Often hear robotic voice

- Store tones, then put them together
  - The transition is the difficult thing to do

Speaker Recognition

- Tell which person it is (voice print)

- Could be important for monitoring meetings

Speech Recognition

- Primarily identifying words

- Improving all the time
- Commercial systems:
  - IBM/Nuance ViaVoice, Ford Sync ...

Recognition Dimensions

- Speaker dependent/independent
  - Parametric patterns are sensitive to speaker
  - With training can get better
- Vocabulary
  - Some are getting 50,000+ words
- Isolated word vs. continuous speech
  - Continuous: where words stop & begin
  - Typically a pattern match, no context used

Recognition Systems

- Typical system has 5 components:
    - Speech capture device - Has analog -> digital converter
    - Digital Signal Processor - Gets word boundaries, scales, filters, cuts out extra stuff
    - Preprocessed signal storage - Processed speech buffered for recognition algorithm
    - Reference speech patterns - Stored templates or generative speech models for comparisons
    - Pattern matching algorithm - Goodness of fit from templates/model to user's speech

Natural Language Understanding

- Putting *meaning* to the words
- Input might be speech or could be typed
- Holy grail of Artificial Intelligence problems

NL Factors/Terms

- Syntactic
  - Grammar or structure
- Prosodic
  - Inflection, stress, pitch, timing
- Pragmatic
  - Situated context of utterance, location, time
- Semantic
  - Meaning of words

SR/NLU Advantages

- Easy to learn and remember
- Powerful
- Fast, efficient (not always)
- Little screen real estate

SR/NLU Disadvantages

- Doesn’t work well enough yet
- Assumes knowledge of problem domain
  - Not prompted, like menus
- Requires typing skill (if keyboard)
- Enhancements are invisible
- Expensive to implement

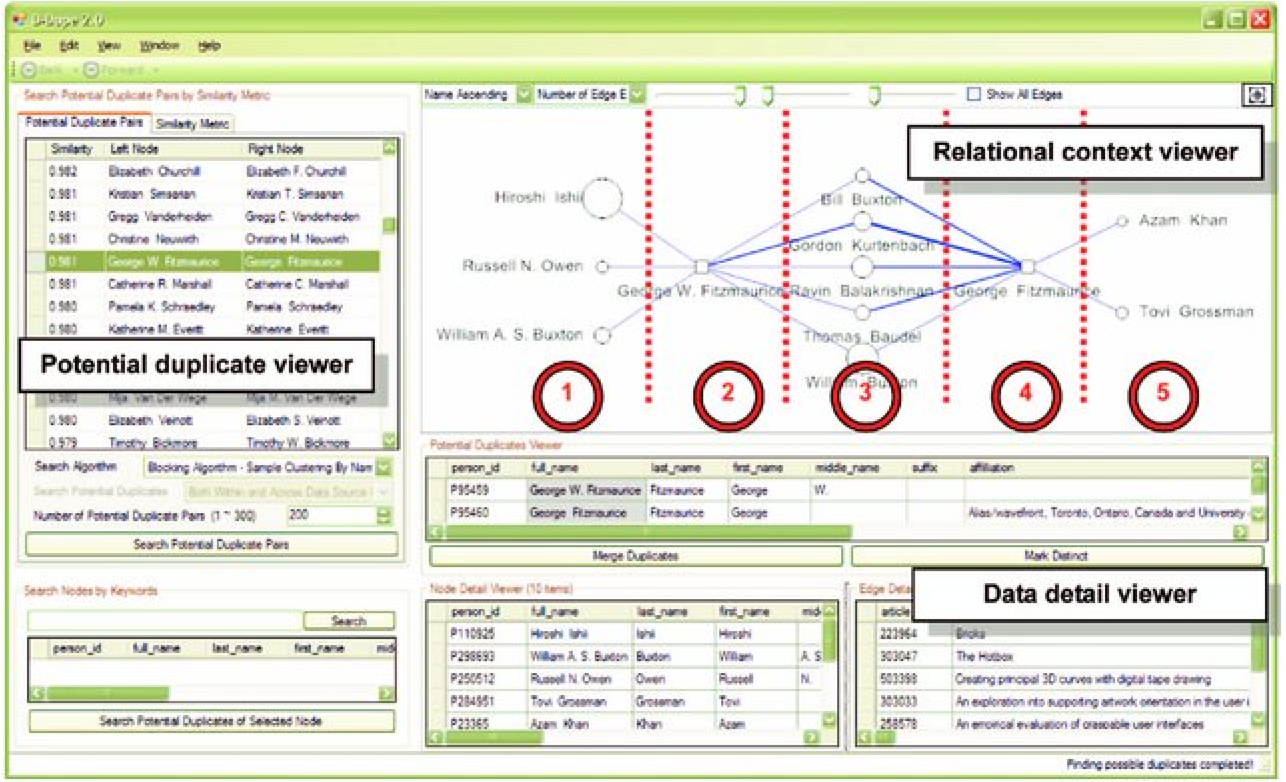
Good in Situations

- Hands busy
- Mobility required
- Eyes occupied
- Conditions preclude use of keyboard
- Visual impairment
- Physical limitation

Multiple Views (Windows) Management

Coordinated windows

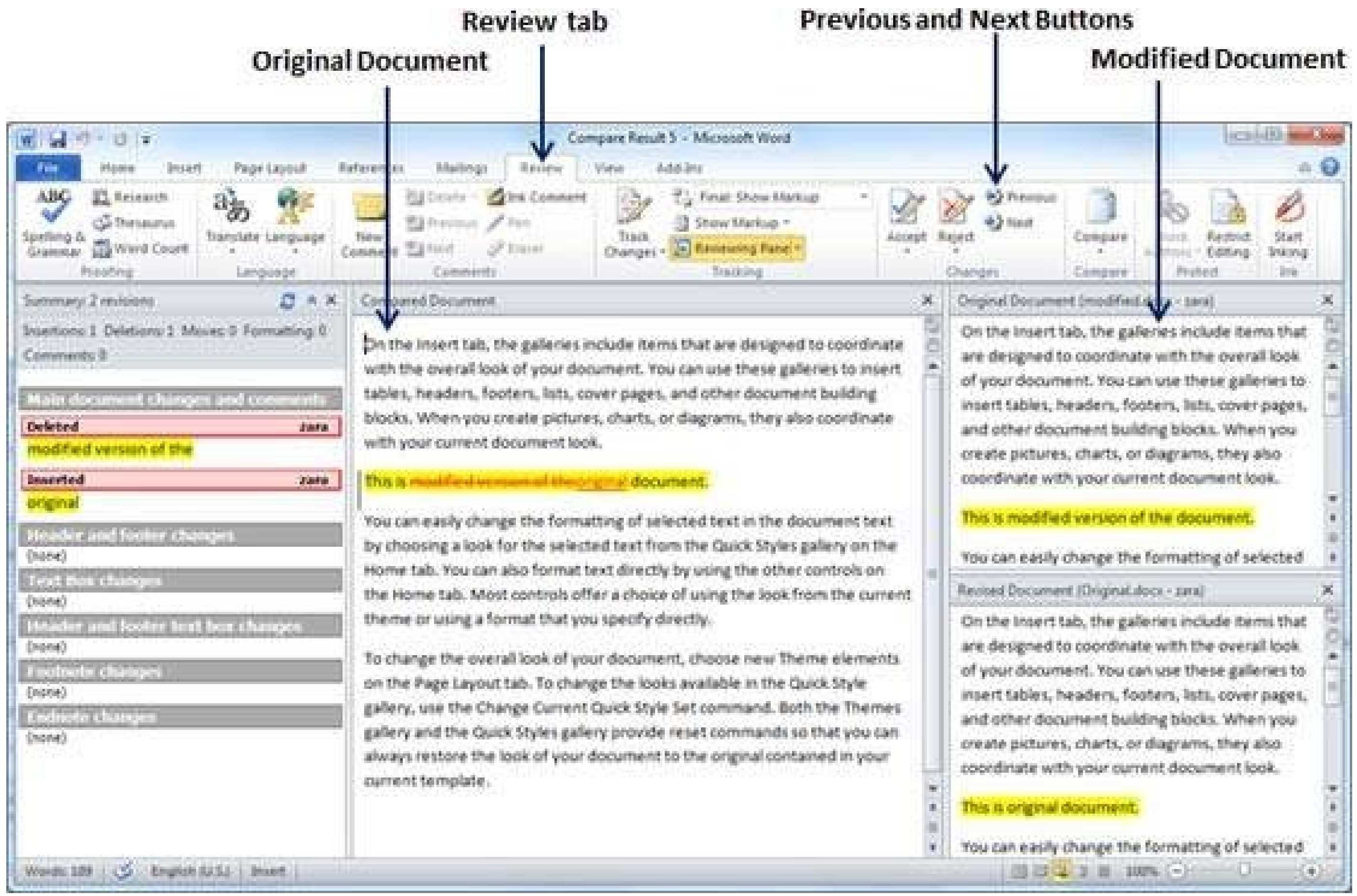
- Windows that appear, change contents, resize automatically, and close as a direct result of user actions in the task domain



https://www.researchgate.net/publication/5253325_Interactive_Entity_Resolution_in_Relational_Data_A_Visual_Analytic_Tool_and_Its_Evaluation/figures?lo=1

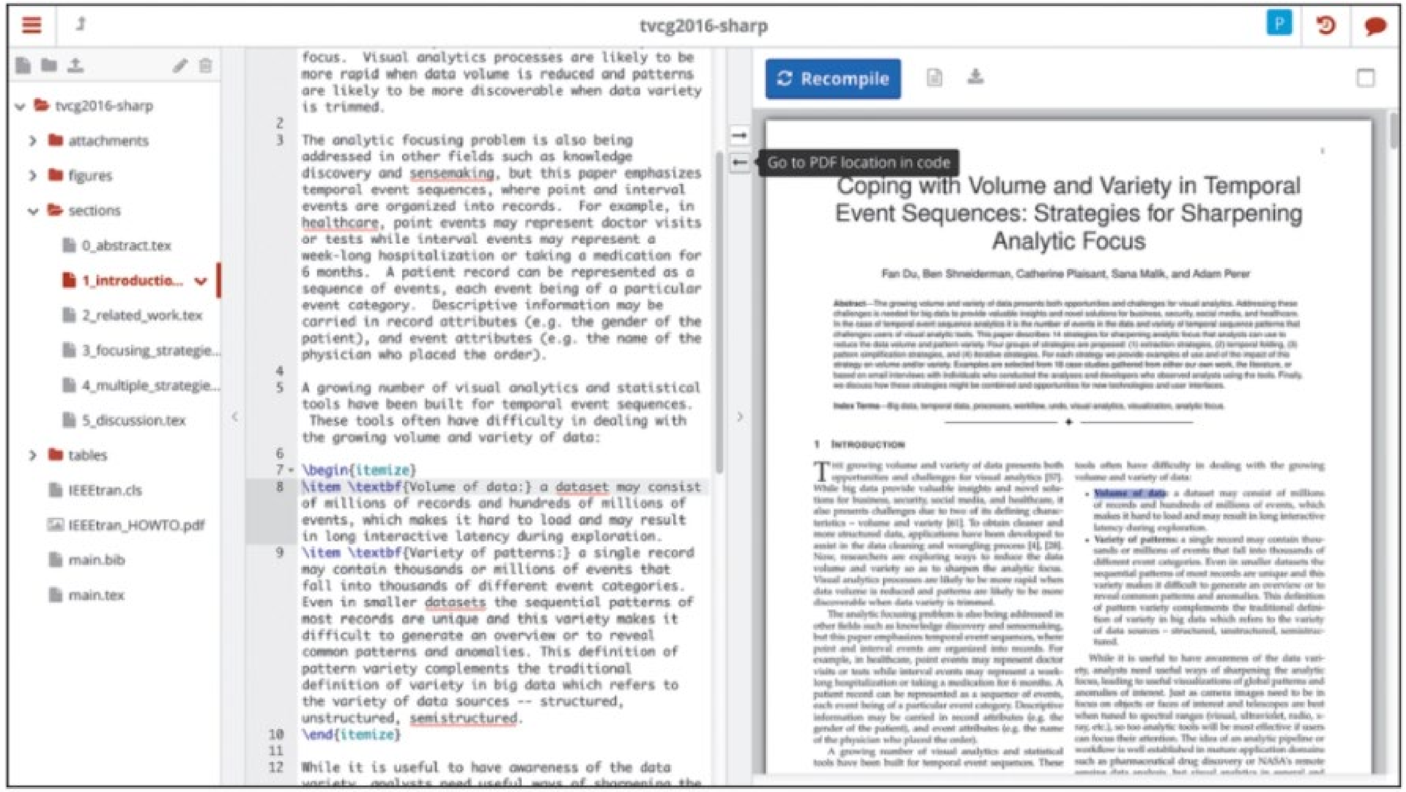
Coordinated windows

- Synchronized scrolling
  - A simple coordination is synchronized scrolling, in which the scroll bar of one window is coupled to another scroll bar, and action on one scroll bar causes the other window’s contents to scroll in parallel.



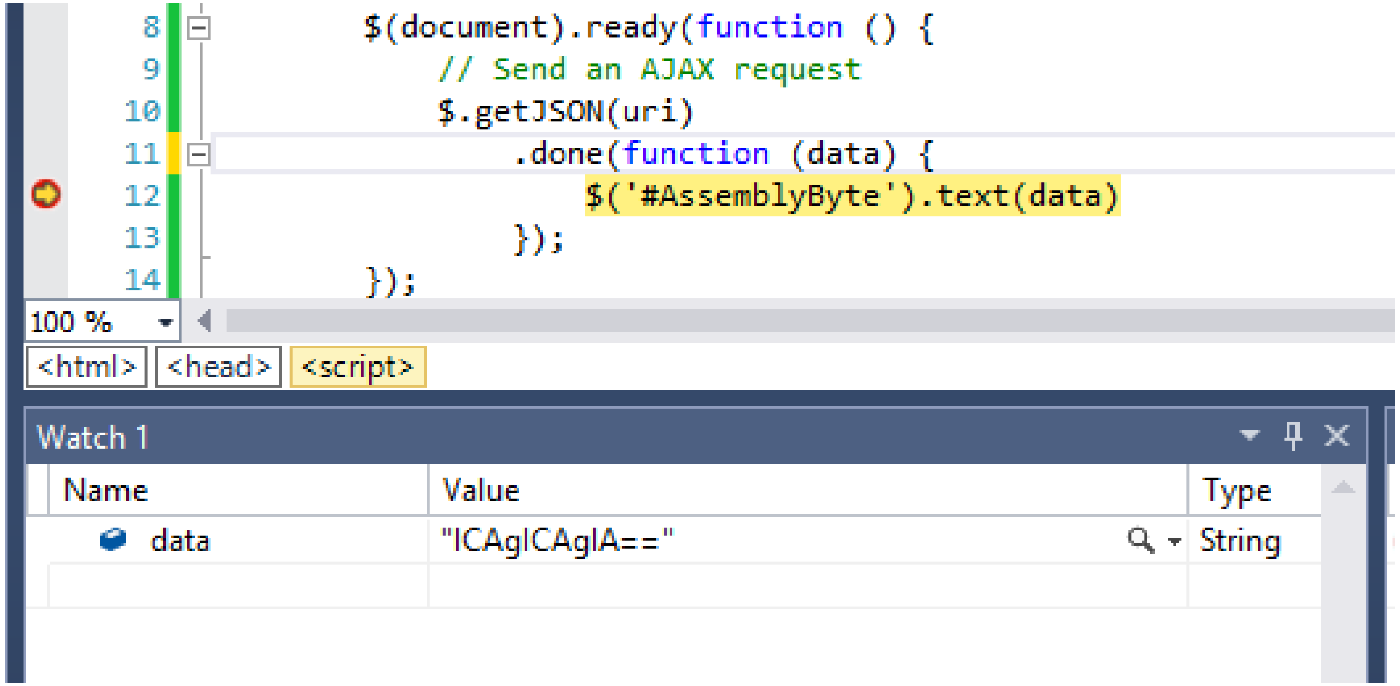
Coordinated windows

- Hierarchical browsing
  - Coordinated windows can be used to support hierarchical browsing



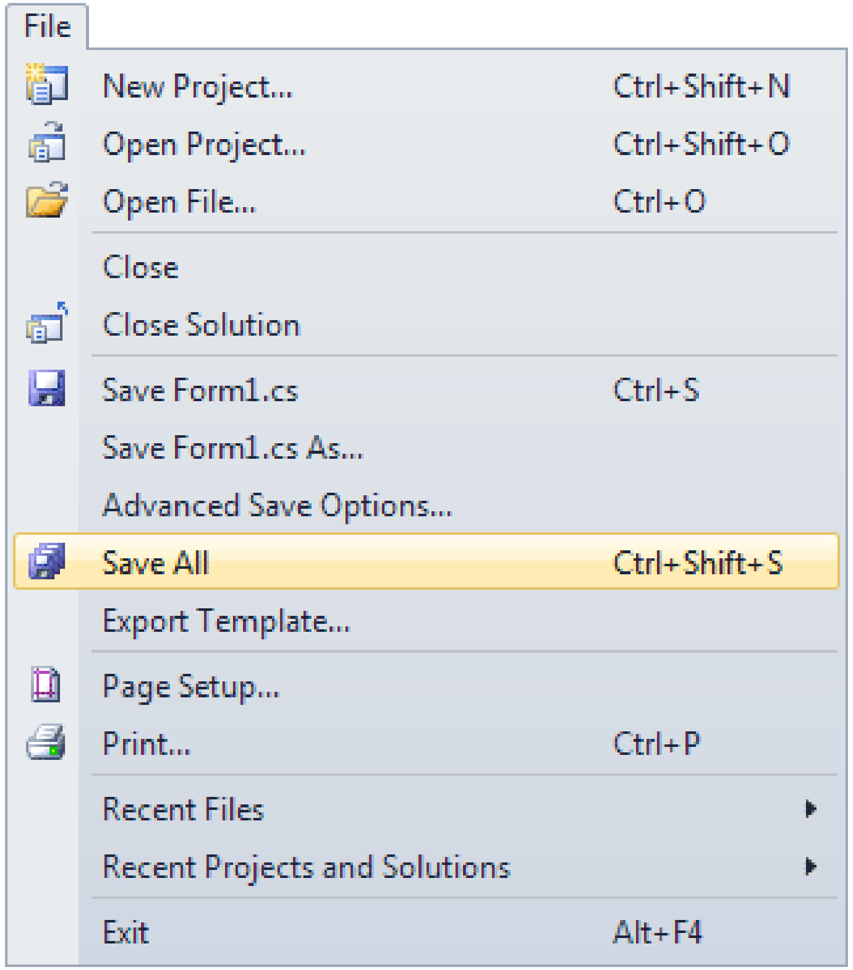
Coordinated windows

- Opening/closing of dependent windows.
  - One option on opening a window is to simultaneously open dependent windows in a nearby and convenient location



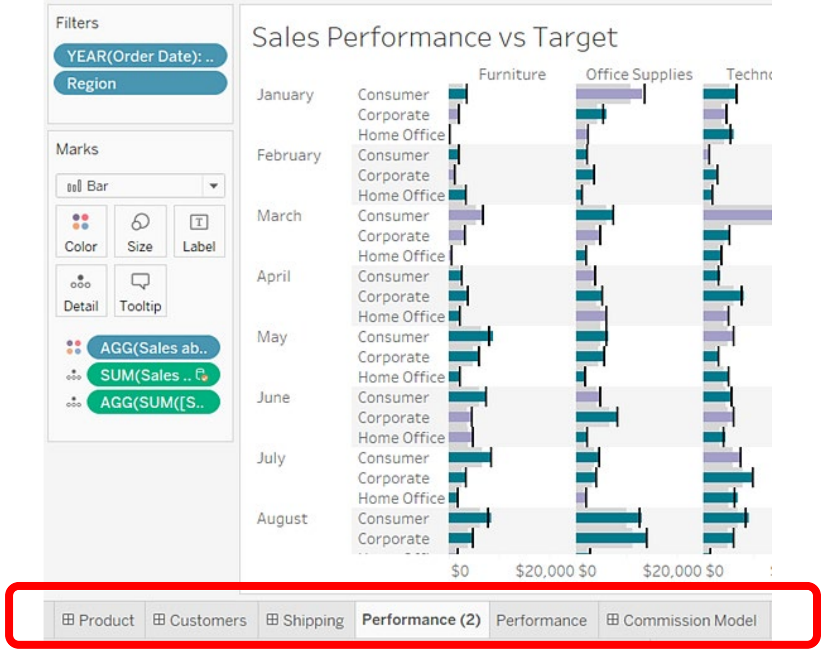
Coordinated windows

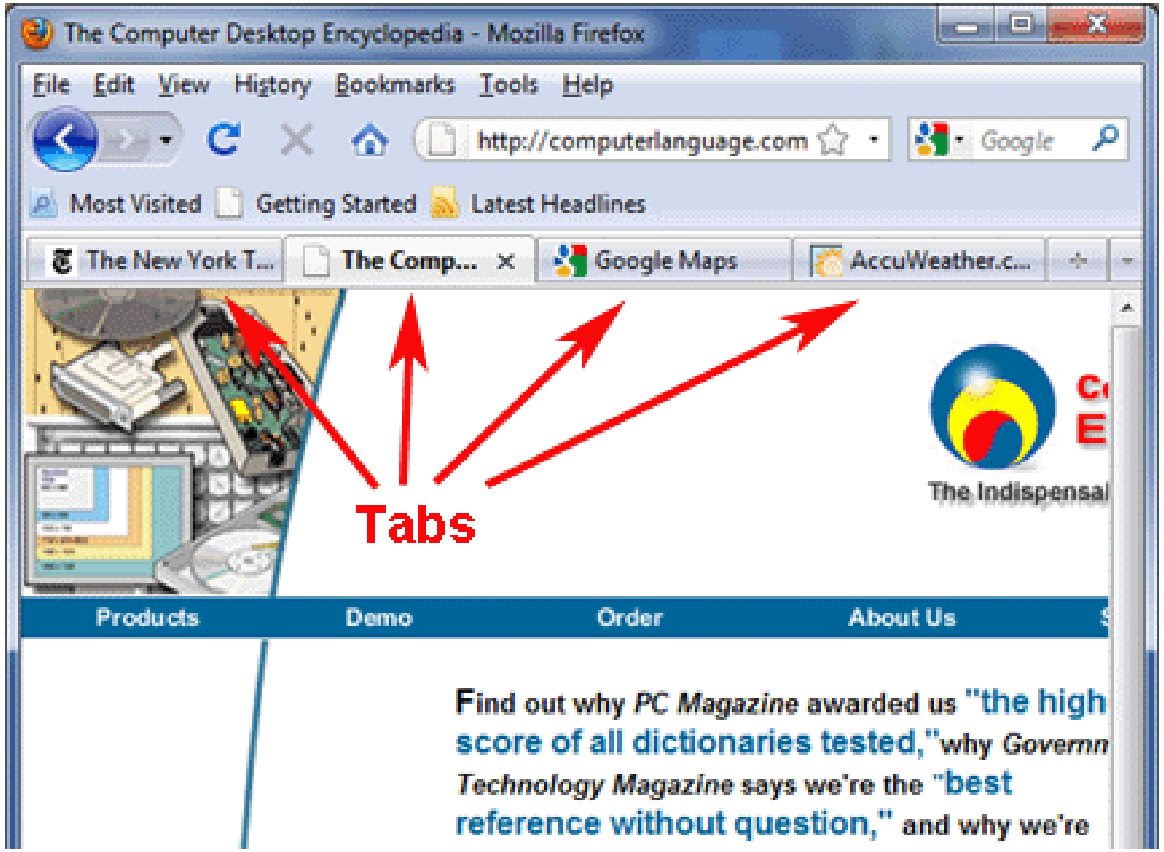
- Saving/opening of window state.
    - A natural extension of saving a document or a set of preferences is to save the current state of the display with all the windows and their contents.



Coordinated windows

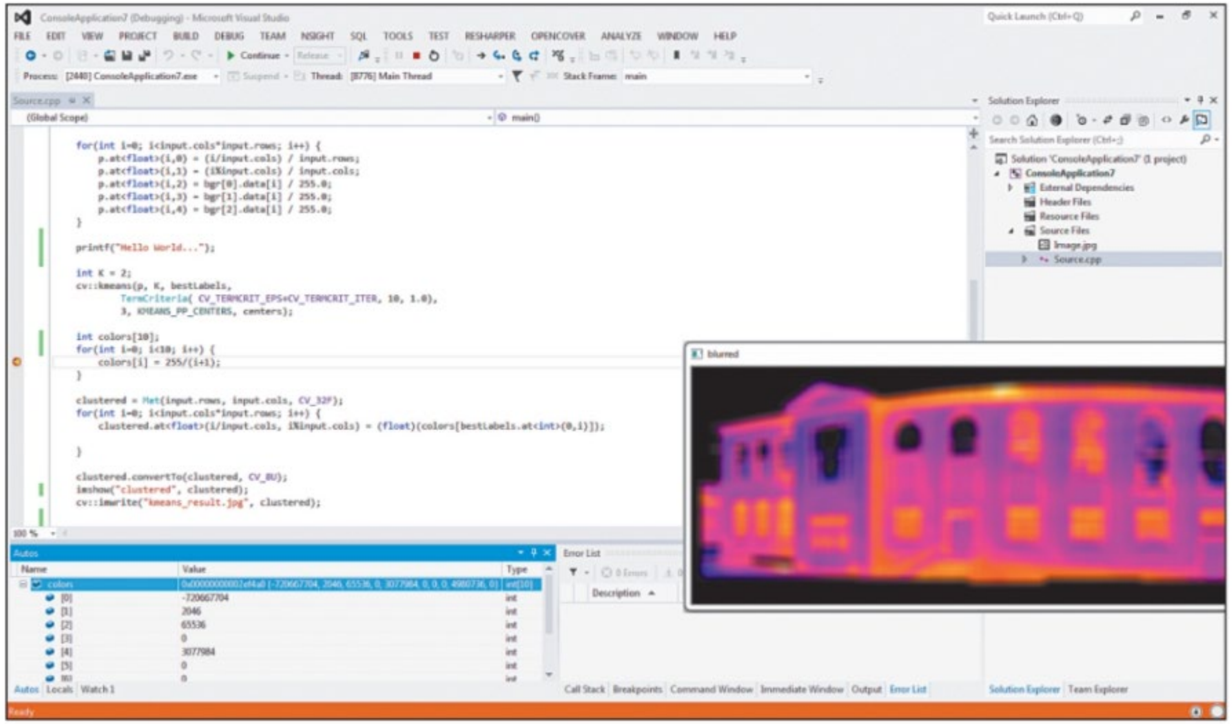
- Tabbed browsing.
  - Browser tabs allow users to view multiple webpages in the same browser without the need to open a new browser session.





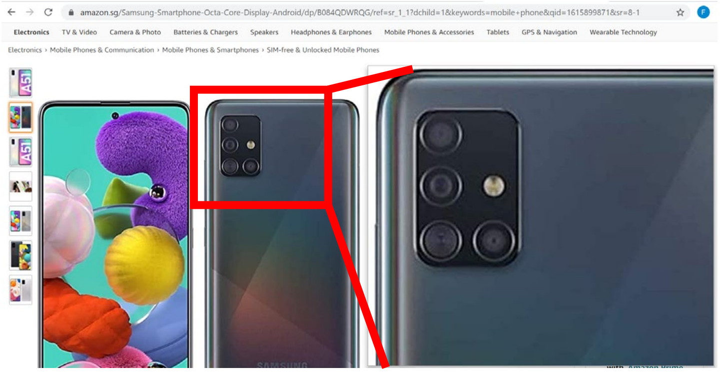
Coordinated windows

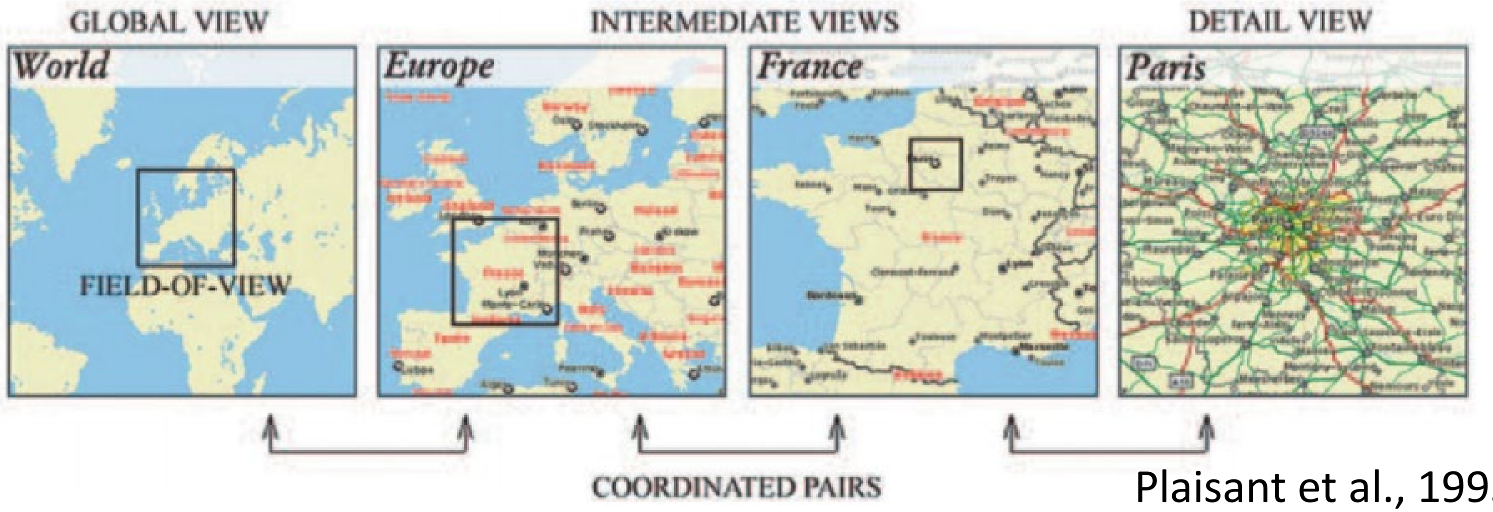
- Tiled or overlapping windows.
  - Windows can automatically be resized and arranged so that they do not overlap each other.
  - Overlapping windows are sometimes referred to as overlaid or cascading windows



Browsing large views

- Image browsing, which enables users to work with large maps, circuit diagrams, magazine layouts, photos, or artwork
- Users see an overview in one window and the details in a second window.





Plaisant et al., 1995

Website and Mobile UI Design

Website design

- Early websites were largely text-based, providing hyperlinks
- Concern was with how best to structure information to enable users to navigate and access them easily and quickly
- Nowadays, more emphasis is on making pages distinctive, striking, and aesthetically pleasing
- Need to think of how to design information for multiple platforms—keyboard or touch?
  - For example, smartphones, tablets, and PCs

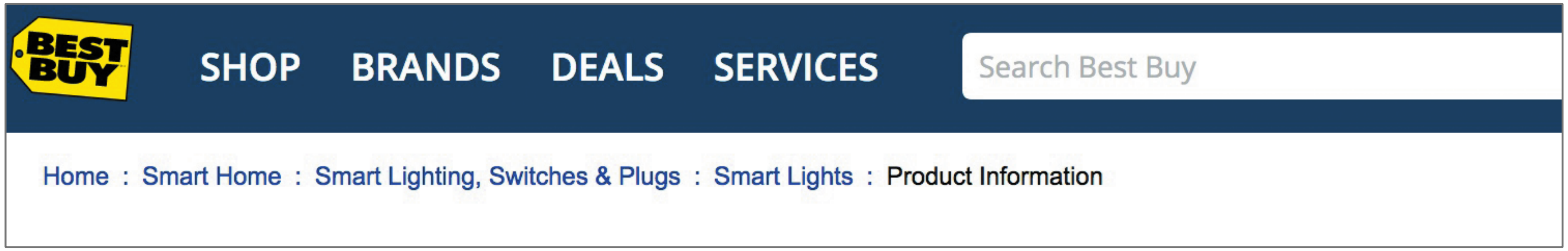
Usability versus Aesthetics?

- Vanilla or multi-flavor design?
  - Ease of finding something versus aesthetic and enjoyable experience
- Web designers are:
  - "thinking great literature"
- Users read the web like a:
  - "billboard going by at 60 miles an hour" (Krug, 2014)
- Need to determine how to brand a web page to catch and keep 'eyeballs'

Breadcrumbs for navigation

Breadcrumbs are category labels:

- Enable users to look at other pages without losing track of where they have come from
- Very usable
- Enable one-click access to higher site levels
- Attract first time visitors to continue to browse a website having viewed the landing page



Web design considerations

- Three core questions to consider when designing any website (Veen’s, 2001)

  1. Where am I?
  2. Where can I go?
  3. What’s in here?

Mobile interfaces

- Handheld devices intended to be used while on the move
- Have become pervasive, increasingly used in all aspects of everyday and working life
  - For example, phones, fitness trackers, and smartwatches
- Larger-sized tablets used in mobile settings
  - Including those used by flight attendants, marketing professionals, and at car rental returns

Even QR codes and smartphones

More personal

- One device per person
- Freedom, more convenient to use
- “Emotional” connection
- 46% say something they “cannot live without” (Pew Research, US, 2015)
- 63% of people felt lost if their smartphone was not in easy reach (Foolproof UK, 2012 Study)

Design considerations

- Mobile interfaces can be cumbersome to use for those with poor manual dexterity or ‘fat’ fingers

- Key concern is hit area:
  - Area on the phone display that the user touches to make something happen, such as a key, an icon, a button, or an app
  - Space needs to be big enough for all fingers to press accurately
  - If too small, the user may accidentally press the wrong key
  - Fitts’ law can be used to help design right spacing
    - Minimum tappable areas should be 44 points x 44 points for all controls

Users of mobile devices

- Users subject to disturbances
- Lower attention span
- Intermittent interaction
- **No** full concentration
- Location changes often

Design guidelines (1/2)

- Design for simplicity
- Minimize user input
- Minimize vertical scrolling, avoid horizontal scrolling
    - “Above the fold” applies here too! (present attention-grabbing headlines, content, and imagery on the top half of the page)
- Prioritize information on each screen
- Useful error messages, feedback
- Ensure fast system response time

Design guidelines (2/2)

- Relate visual precedence to task importance

- Need to be <u>focused</u>, more is not better

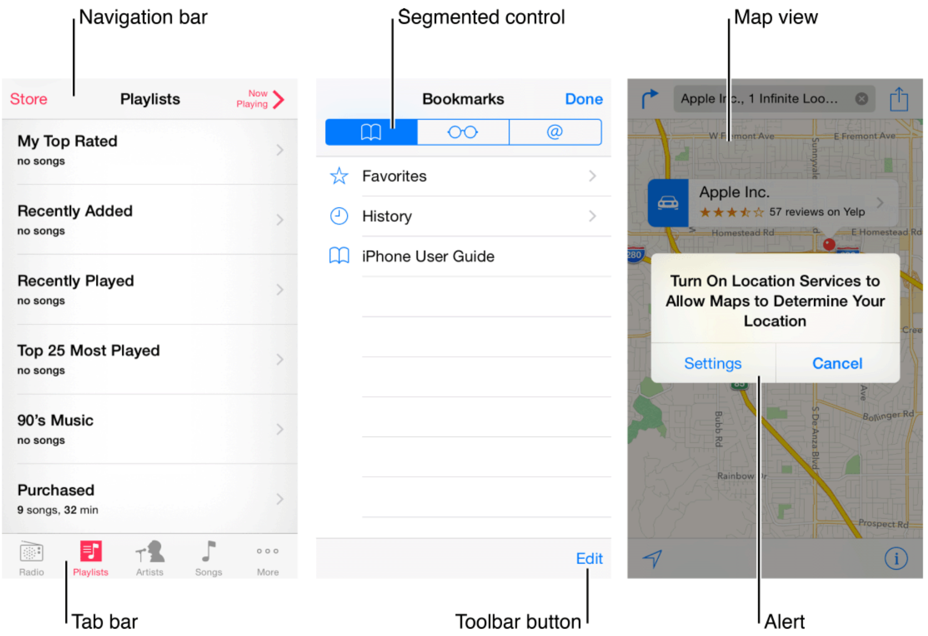
- Navigation should be narrow and shallow
  - Respect physical and mental effort

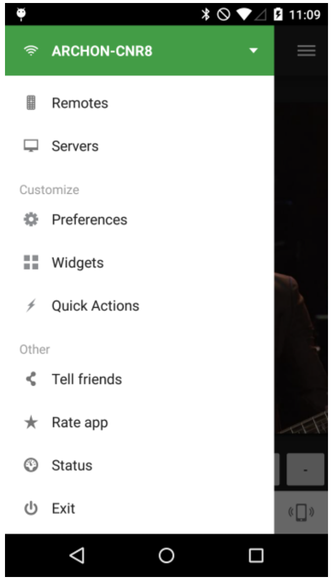
- Keep the most important features
  - Leave some features out, reduce functionality

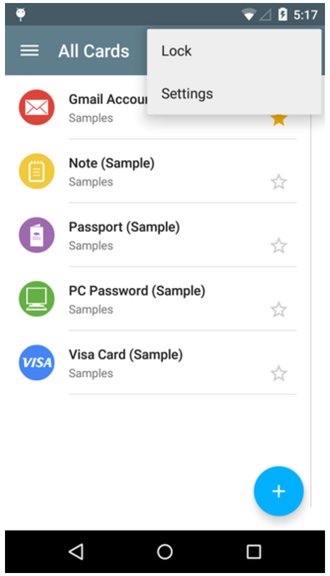
- Unique new features possible due to mobility
  - What are they? Take advantage of them

Navigation Models

- Different OS, different models
- Pick one and stick to it for the app
- Different navigation model
- Different widgets



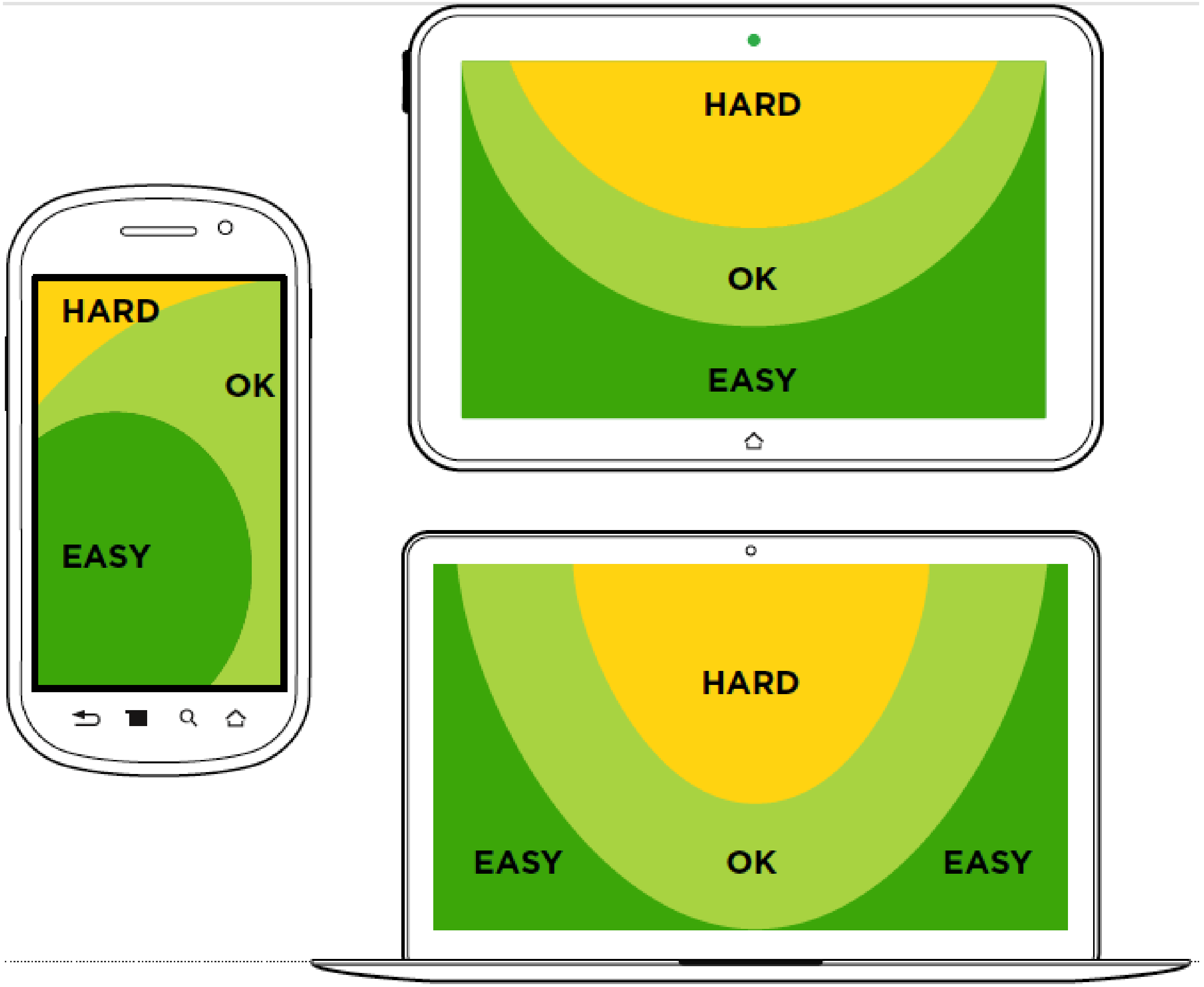




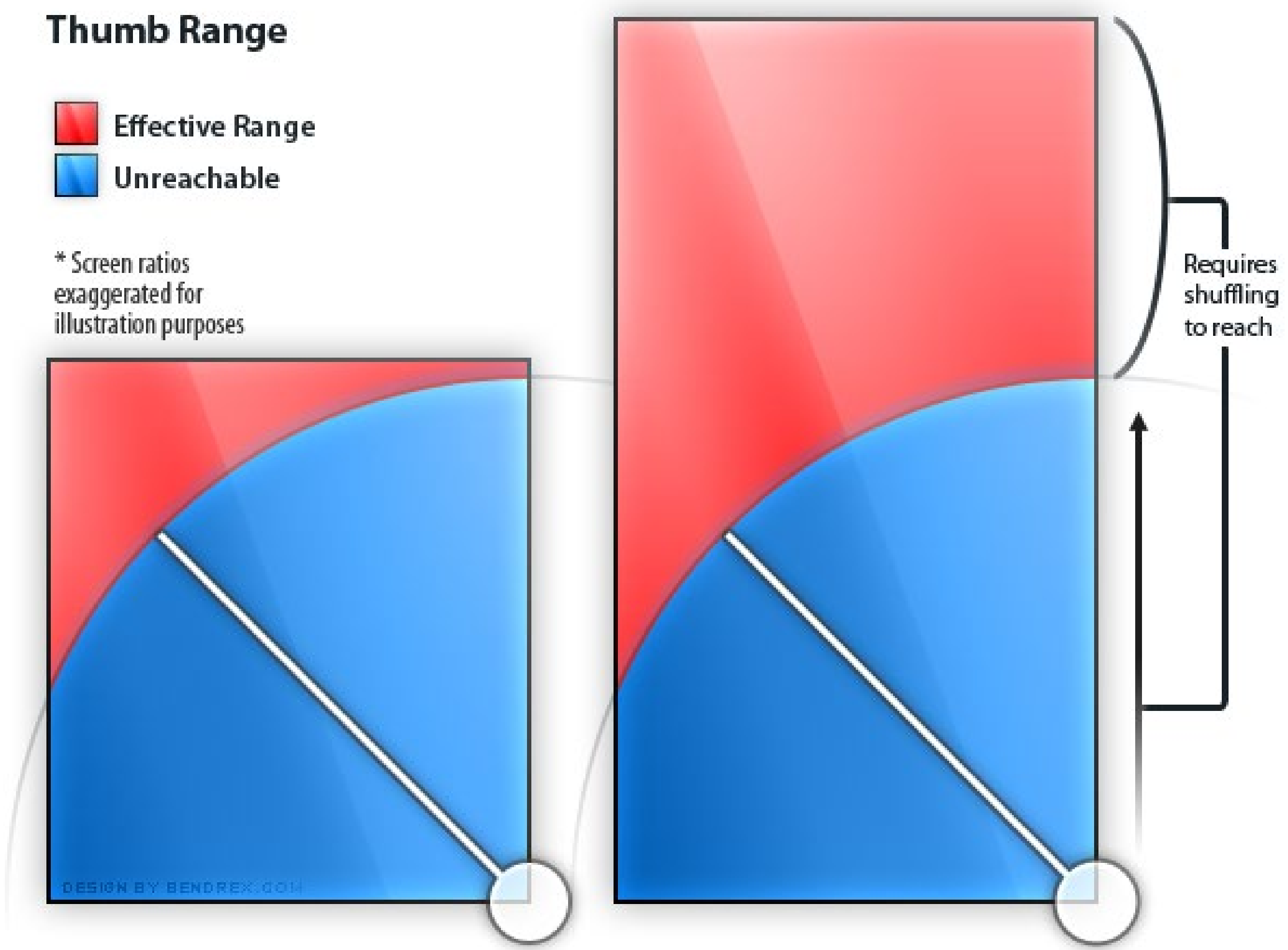
Input Methods & Gestures

- Mostly thumbs
  - Came with the advent of touchscreens
- Minimum target size
  - Thumb friendly UI is 44-48 pixels
- Direct manipulation
  - Removal of abstractions like mouse and trackpad
- Limited reach on screen
  - Put controls at the bottom of the screen
  - Avoid too much scrolling

Comfortable Touch Zones



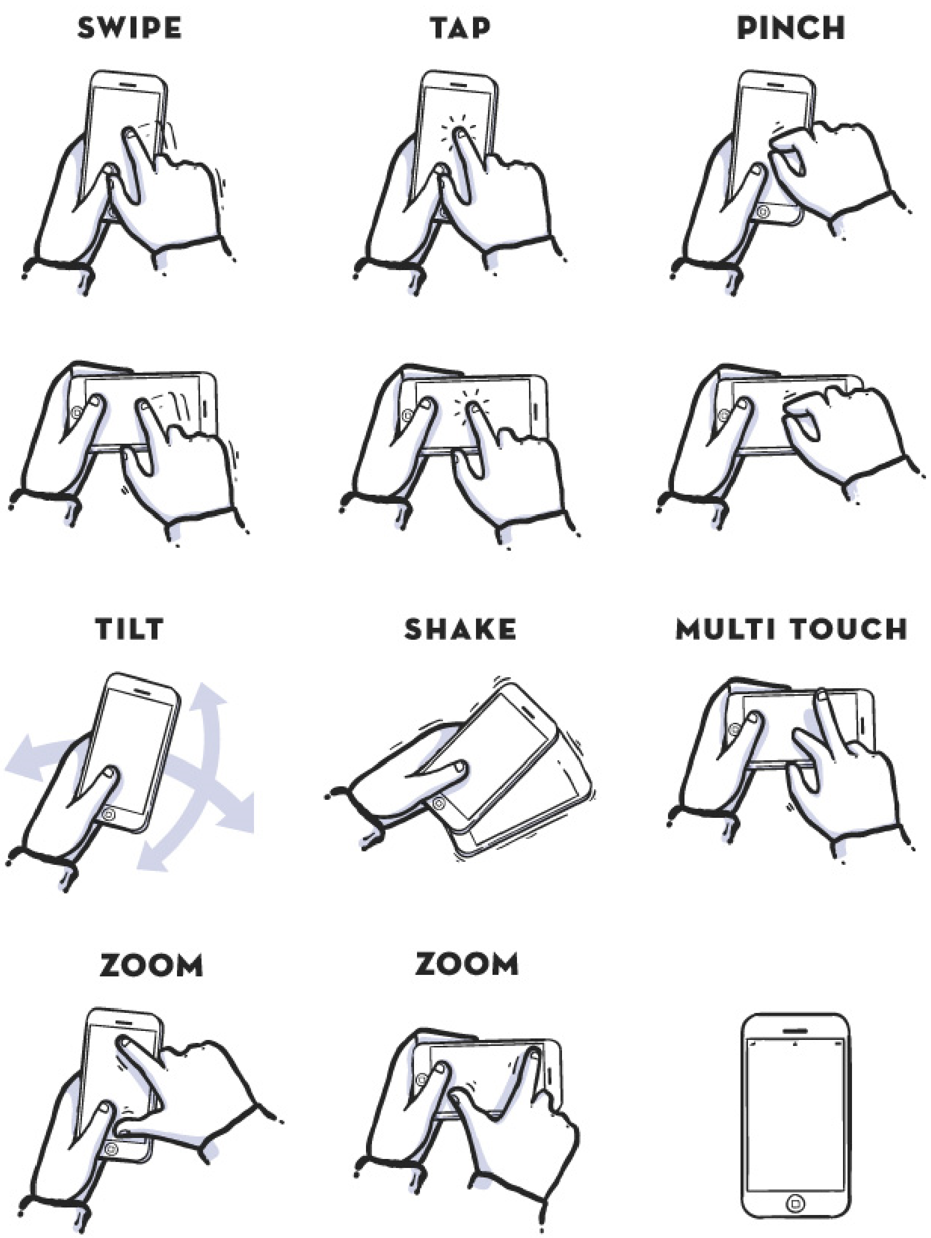
Thumb Range



Thumb Range
Effective Range
Unreachable
* Screen ratios exaggerated for illustration purposes
Requires shuffling to reach
DESIGN BY BENDREX.COM

Input Methods & Gestures

- Reduce typing
    - Typing is hard
    - Autocorrect is hilarious
- Use the correct keyboard for the correct situation
- Common Gestures
    - Swipe left or right
    - Pinch to zoom (2 fingers)
    - Rotate (2 fingers)
- Newer Gestures
    - Press & Hold (3D Touch)
    - More than 2 fingers?


SWIPE
TAP
PINCH
TILT
SHAKE
MULTI TOUCH
ZOOM
ZOOM

Recap

- Direct manipulation
- Fitts' Law
- Steering Law
- Interactive devices
- Multi-window management
- Web/mobile UI design